Innovative Photoresist Removal Technology for Wafer Level Packaging

Cass Shang, Mihaela Cernat, Tomoko Aoki, Anna Phung, Anthony Rardin
Dupont EKC Technology Inc.

Abstract

A newly developed formulation for thick photo resist removal has been jointly developed by DuPont's EKC and APL businesses to enable high-performance wafer bumping. This paper describes the compatibility and stripping performance achieved with an innovative photoresist removal technology on various sample wafers with liquid and dry film photo resist. The results presented will open up new opportunities for advanced bumping applications which require pitches of 100 µm and below.

Introduction

To meet high dense fine pitch requirements for modern wafer packing, in-via electroplating of conductive solder bumps becomes necessary to assure that the plated bumps do not contact each others before reflow. Thick photoresist is needed for constructing of in-via electroplating molds. Depending on the application, either spin on or dry film resist can be used to create the desired array pattern. To achieve high aspect ratio, excellent insulation, heat and chemical resistance, cured photoresist polymer must form a densely crosslinked 3D network to obtain the required physical properties. However, this results in considerable challenges in removing the resist after plating. Further, maintaining a stable bath life with commonly used alkaline/solvent based strippers has proven very difficult. These factors motivated EKC to develop highly chemically reactive resist removal formulations to help break down heavily crosslinked resist polymer. The new remover introduced in this paper is EKC's 2nd generation resist remover based on the company's globally established HDA® technology. The unique chemical properties of hydroxylamine as a strong nucleophile and reducing agent allow for resist stripping and dissolution through a combination of reaction mechanisms involving reduction, chelation, and nucleophilic attack.
Demonstration of the EKC 2nd generation product on resist stripping, metal compatibility, and dielectrics compatibility will be outlined in this paper.

Experiments and Results: Resist Stripping Performance

100µm of DuPont WBR2000 dry film resist wafers:

Dry film was laminated, exposed and developed over a copper seed layer to create the bump array pattern. This was followed by electroplating of metal bumps into the resist pattern.
The removal process was conducted in a beaker on wafer coupons at 55C/20min with 2nd Gen resist remover agitated at 200rpm with a magnetic stir bar. Results are shown in **Figure 1**.

***50µm of DuPont WBR1000 dry film resist wafers*:**

The resist film was laminated, exposed and developed over a copper seed layer to create the bump array pattern. This was followed by electroplating of metal bumps into the resist pattern.

The process was conducted in a beaker on wafer coupons at 65C/30min with the 2nd Gen resist remover agitated at 200rpm with a magnetic stir bar. Results have shown in **Figure 2**.

Figure 1. SEM photos after resist stripping. Left: Pb/Sn(95/5) bumps on Cu. Middle: copper pillar on Cu. Right: AgSn Bumps on copper. Complete stripping without bump and copper attack.

Figure 2. SEM photos after resist stripping. Left: Cu bumps on Cu. Middle: Ni bump on Cu. Right: Gold stud on copper. Complete stripping without bump and copper attack.

60µm of JSR N151 resist wafers:

Dry film was spun on, exposed and developed over copper seed layer to create the bump array pattern. This was followed by electroplating of high lead bumps into the resist pattern.

The process was conducted in a beaker on wafer coupons at both 55C/5min and 40C/10min with the 2nd Generation resist remover agitated at 200rpm with a magnetic stir bar. Results are shown in **Figure 3**.

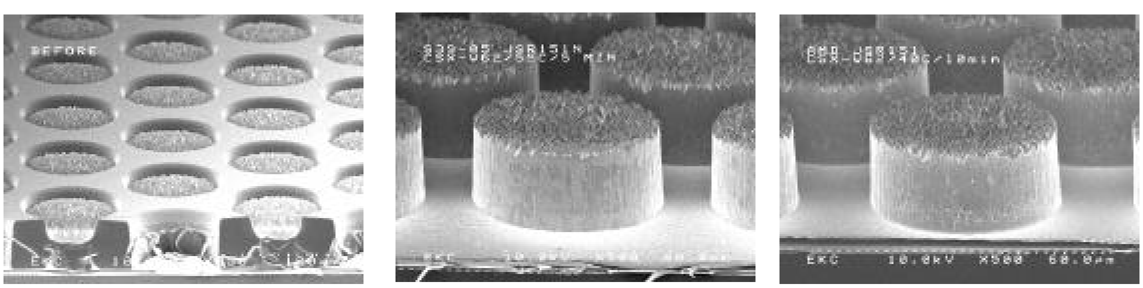


Figure 3. After resist stripping SEMs. Left: Before resist stripping. Middle: 55C/5min. high lead bumps on copper. Right: 40C/10min high lead bumps on copper. Complete stripping without bump attack.

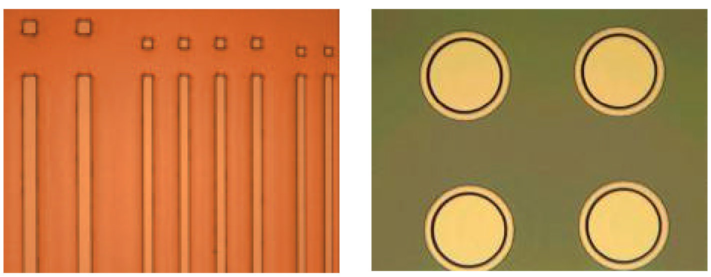
Experiments and Results: Dry Film Resist Loading Test

0.85g of unprocessed DuPont WBR2000 dry film resist (equivalent to one batch of 8 inch wafers) was added to 200g of EKC 2nd Generation resist remover in a beaker. The chemical was maintained at 55C and with a magnetic stir set at 200rpm. 20min passed for the resist to dissolve completely and than anther 0.85g of resist was added to the beaker. This process was repeated until the solution reached the saturation point. The results are summarized in table below.

Assumption used for the calculation:
Wet bench tank: 30L
PR density: 100%
DF thickness: 120µm
DF density: 1.35g/cm^3

Chemistry	Total DF dissolved in 200g of stripping solution (g)	Equivalent to # of 8 inch wafer batches
2nd Gen	6.4	6.6/0.85=7.5
EKC108™	5.95	5.95/0.85=7

Experiments and Results: Compatibility of Dielectric Layer



Process:
2nd Gen Remover /55^{0}C/20min
Curing Condition:
HD4100 (PI): 250^{0}C/2 hrs
HD8820 (PBO): 300^{0}C

Figure 4. The left picture shows a test wafer with cured HD4100 (PI) lines over copper. The structure on the right shows punched-through cured HD8820 (PBO) stopping on copper.

After immersing these wafers in EKC 2nd generation resist remover at 55C for 20min. No dimensional change was observed on either the HD4100 or the HD8820 structures. These results were confirmed by profilometry.

Conclusions

EKC 2nd Gen photoresist remover was successfully designed to meet resist removal needs for advanced packaging technology. Its performance was demonstrated on a wide range of bumping applications. Compatible with passivation materials including cured PI and PBO (HD MicroSystems), the high chemical activity of the remover allows for low-temperature processing, thereby prolonging its bathlife and reducing its cost of ownership significantly.

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